§1. CPD Gyrotron

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Electron cyclotron heating is one of the main methods to produce and heat plasmas in the Large Helical Device (LHD). We have been operating two kinds of gyrotrons at 168GHz and 82.7GHz until last experimental campaign. For the fifth cycle experimental campaign, we installed two collector potential depression (CPD) type gyrotrons at 84GHz in addition to them.

Gyrotron Specification

They are CPD diode gyrotrons. Main specification of the RF output at the gyrotron window is listed in Table. 1. Due to the CPD operation, the total electrical efficiency is more than 50%. These gyrotrons are connected with matching optics units (MOU) guaranteeing the 700kW RF output with pure gaussian beam after MOU. High voltage power supply parameters for the gyrotron are -65kV, 30 A and -90kV, 100 mA for collector and body, respectively.

Table 1. 84GHz CPD gyrotron fundamental parameters

RF output fundamental parameters		
Frequency	(GHz)	84.0
Main output mode		TEM00
RF output power	(kW)	800
Pulse duration	(s)	3

Environment preparation

Figure 1 shows the main circuit of the high voltage power supply for these gyrotrons. We added a 50 kΩ and 150 kΩ "ballast" resistors to protect the gyrotrons from possible damage due to arcings inside the gyrotrons. The gyrotrons need water coolants at cathode, ion pump and cryomagnet.

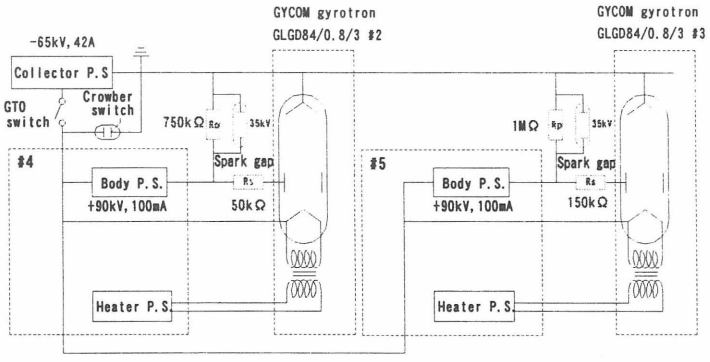

Fig. 1. Main circuit of the gyrotrons and power supplies.

Confirmation of the output

All gyrotrons delivered are tested up to the full specification and recorded the operation more than subsequent 10 shots of 3-second pulse. The window output power measured at the calorimetric load was 802 kW with the pulse length of 100 ms. Here, operating parameters for this operation were:

Collector Voltage	63 kV
Body Voltage	90 kV
Magnet Current	51.47 A
Beam Current	26.4 A
Body Current	55.8 mA

The gyrotron window loss power is measured simultaneously with the output power. The fraction of the power loss measured at the window to total power at the calorimetric load was 1.28 %. Using the brick dummy load for the longer pulse operation, we succeeded in 3s pulse operation of 800kW. We tested another gyrotron with the identical procedure and confirmed the fulfillment of the specification. These new 84GHz gyrotrons worked well during the fifth cycle experiment and much contributed to obtain high electron temperature plasmas.

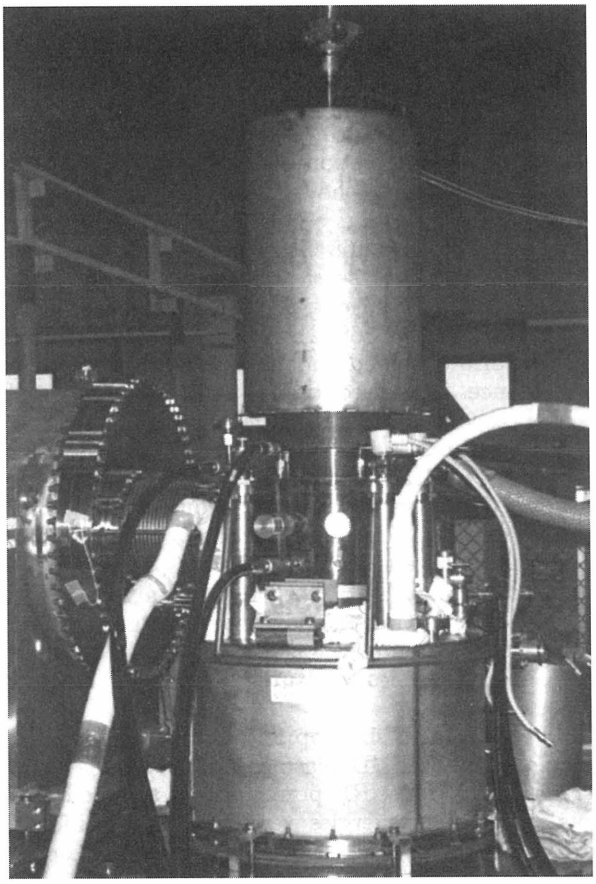

Fig. 2. Photograph of 84GHz CPD gyrotron on the cryomagnet.